De fluviatiele ontwikkeling in het Niersdal op de overgang van het Weichsel Laat Glaciaal naar het Holoceen

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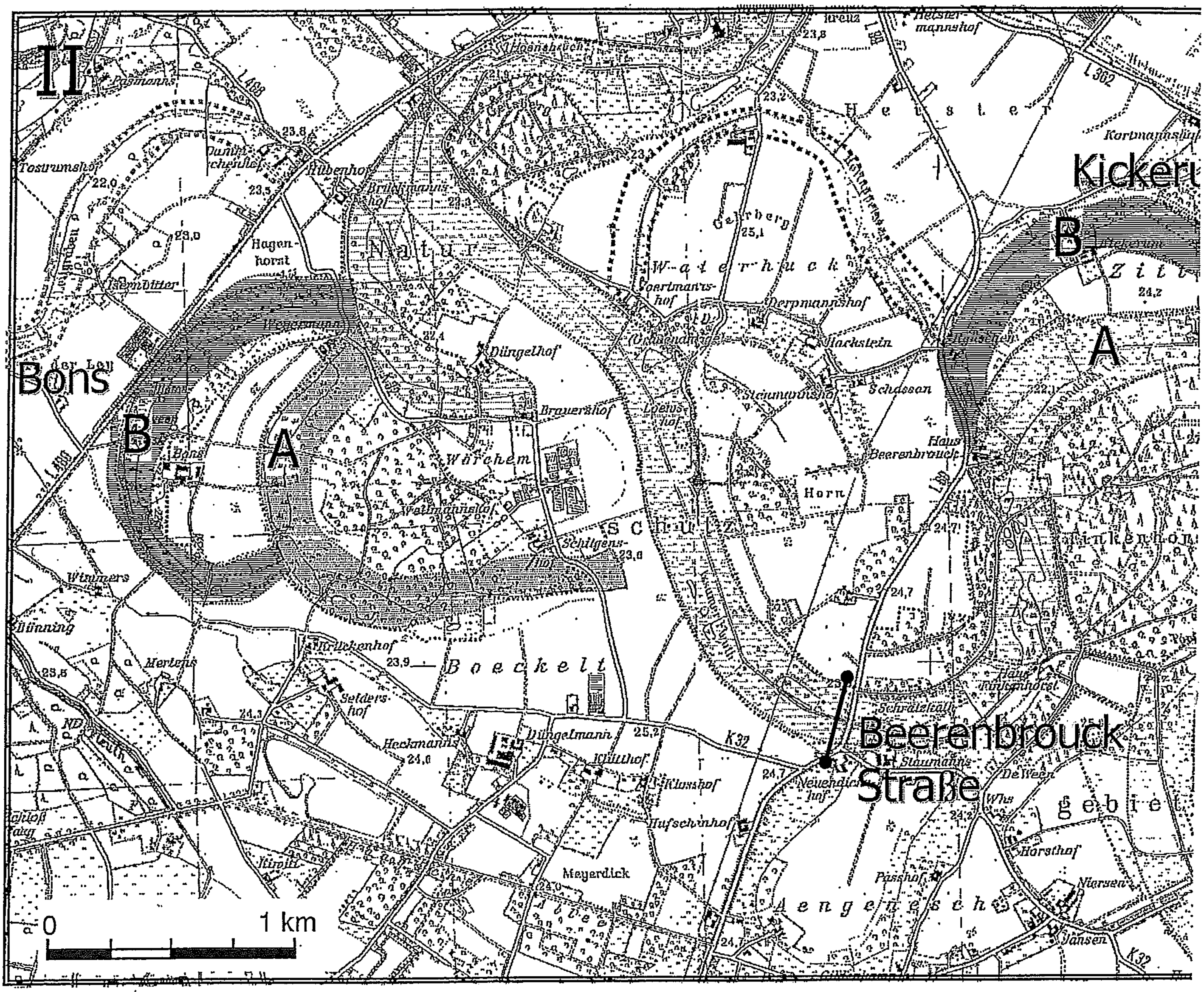

De Fluviatiele ontwikkeling in het Niersdal op de overgang van het Weichsel Laat Glaciaal naar het Holoceen

Kees Kasse
Sjoerd Bohncke
Wim Hoek

CLIMATE AND VEGETATION CHANGE AND LATE GLACIAL FLUVIAL RESPONSE OF THE NIERS-RHINE (WESTERN GERMANY)

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Summary

The Niers valley was part of the Rhine system that came into existence during the maximum Saalian glaciation and was abandoned at the end of the Weichselian. The aim of the study was to explain the Late Pleniglacial and Late Glacial fluvial dynamics and to explore the external forcing factors climate change, tectonics and sea level.
The sedimentary units have been investigated by large-scale coring transects and detailed cross-sections over abandoned channels. The temporal fluvial development has been reconstructed by means of geomorphological relationships, pollen analysis and ^{14}C dating.
The Niers-Rhine experienced a channel pattern change from braided, via a transformational phase to meandering at the Late Pleniglacial to Late Glacial transition. This change in fluvial style is explained by the early Late Glacial climate amelioration (at c. 12,5 ka ^{14}C BP) and climate-related hydrological, lithological and vegetation changes. A delayed fluvial response of c. 400 years (transitional phase) was established. The channel transformations are not related to neotectonic effects and sea-level changes. Successive river systems have similar gradients of c. 35-40 cm/km.
A meandering river system dominated the Allerød and Younger Dryas periods. The threshold towards braiding was not crossed during the Younger Dryas. The final abandonment of the Niers-Rhine was dated at the Younger Dryas to Holocene transition. The first traces of Laacher See pumice have been found in the Niers valley indicating that the Niers-Rhine still existed in the Younger Dryas period.

Fig. 1 Geological setting of the Niers Valley

The Niers valley is situated in the southeastern Netherlands and adjacent Germany. The valley was formed during the maximum Saalian glaciation. Then, the Rhine flow was diverted to the west by the southward migration of the Scandinavian ice sheet. During (parts of) the Weichselian the Niers valley was the westernmost Rhine course. At the end of the Weichselian the Niers-Rhine was finally abandoned.

Fig. 2 Late Pleniglacial to Holocene floodplain levels in the Niers valley

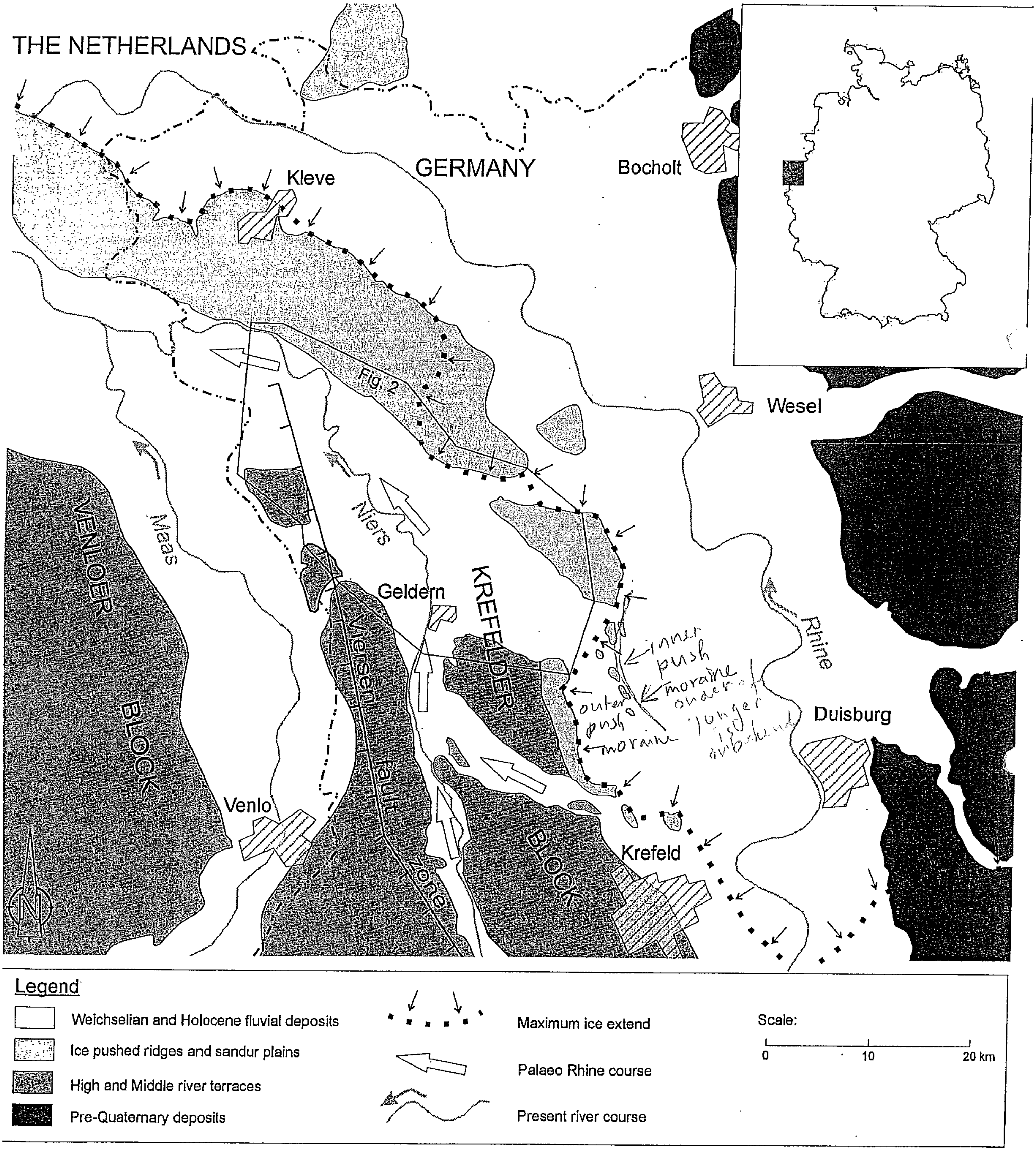

THE NETHERLANDS
GERMANY
Kleve
Bocholt
Wesel
Fig. 2
Maas
Niers
Geldern
KREFELDER
BLOCK
VENLOER
BLOCK
Viersen
fault
zone
Venlo
Krefeld
Rhine
Duisburg
N
inner push moraine
outer push moraine
ouder of jonger is onbekend
Legend
Weichselian and Holocene fluvial deposits
Ice pushed ridges and sandur plains
High and Middle river terraces
Pre-Quaternary deposits
Maximum ice extend
Palaeo Rhine course
Present river course
Scale:
0
10
20 km

Fig. 1.

Bijlage 1: Riviersystemenkaart Niersdal

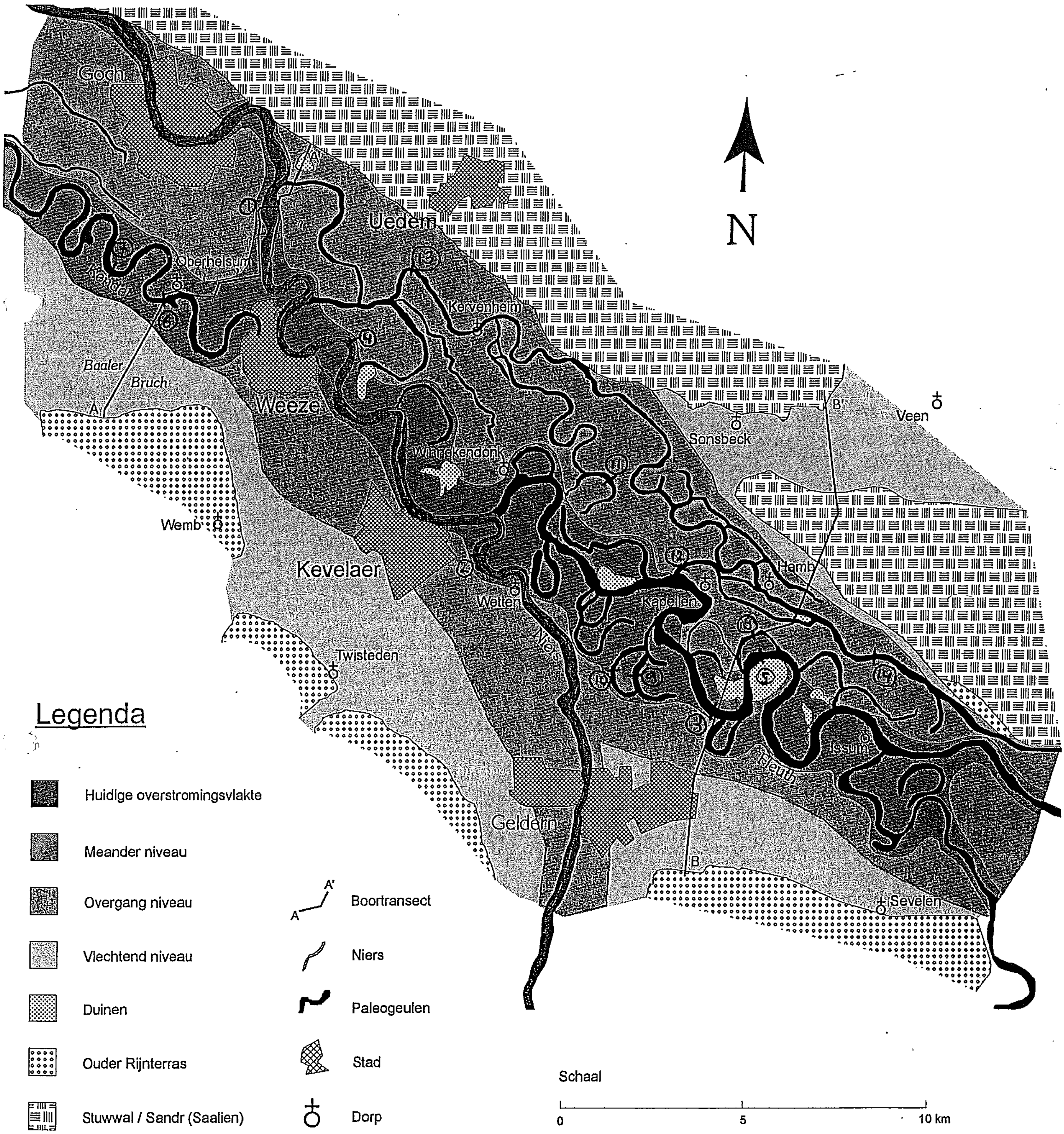
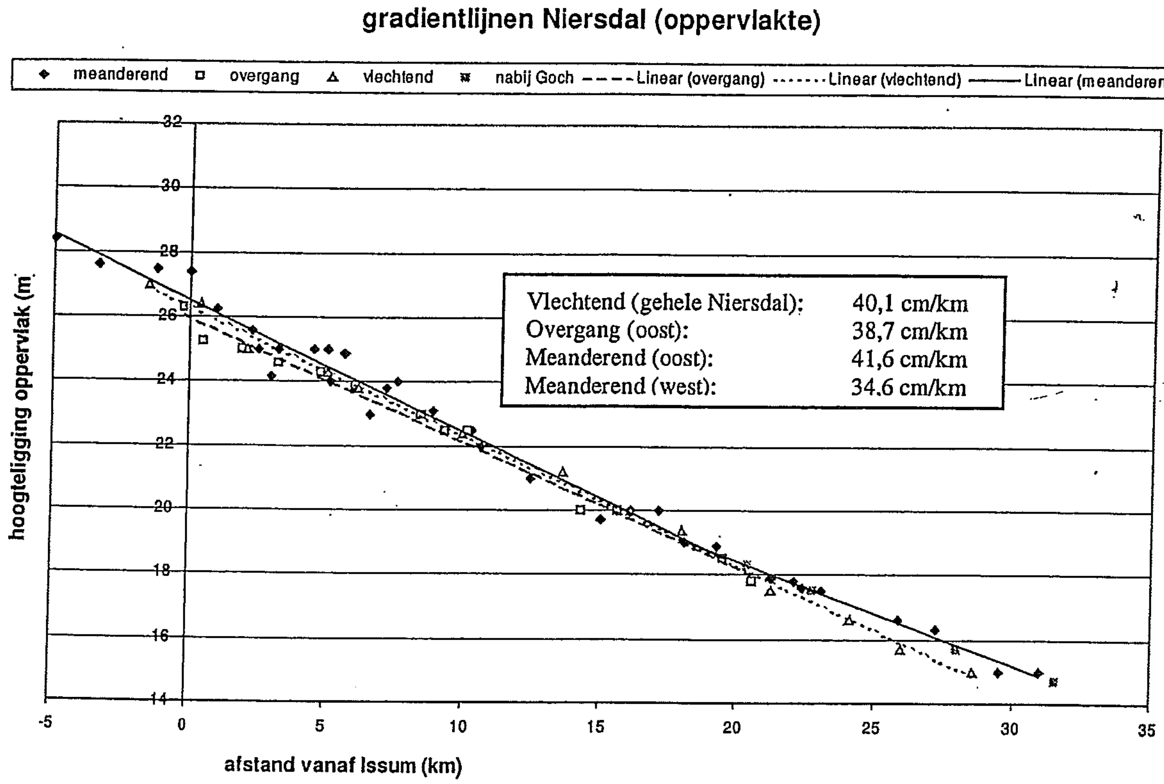


Fig. 2.



Figuur 3.: : datapunten en gefitte regressie (gradiënt)lijnen voor het vlechtend riviersysteem, overgangssysteem en het meanderend systeem. De datapunten westelijk van Goch, waarvan het nog onduidelijk is tot welk systeem ze behoren, zijn apart weergegeven zonder regressielijn. Bovenin de figuur zijn de hellingen van de systemen weergegeven. Bij meanderend is onderscheid gemaakt tussen oost en west.

Fig. 4a

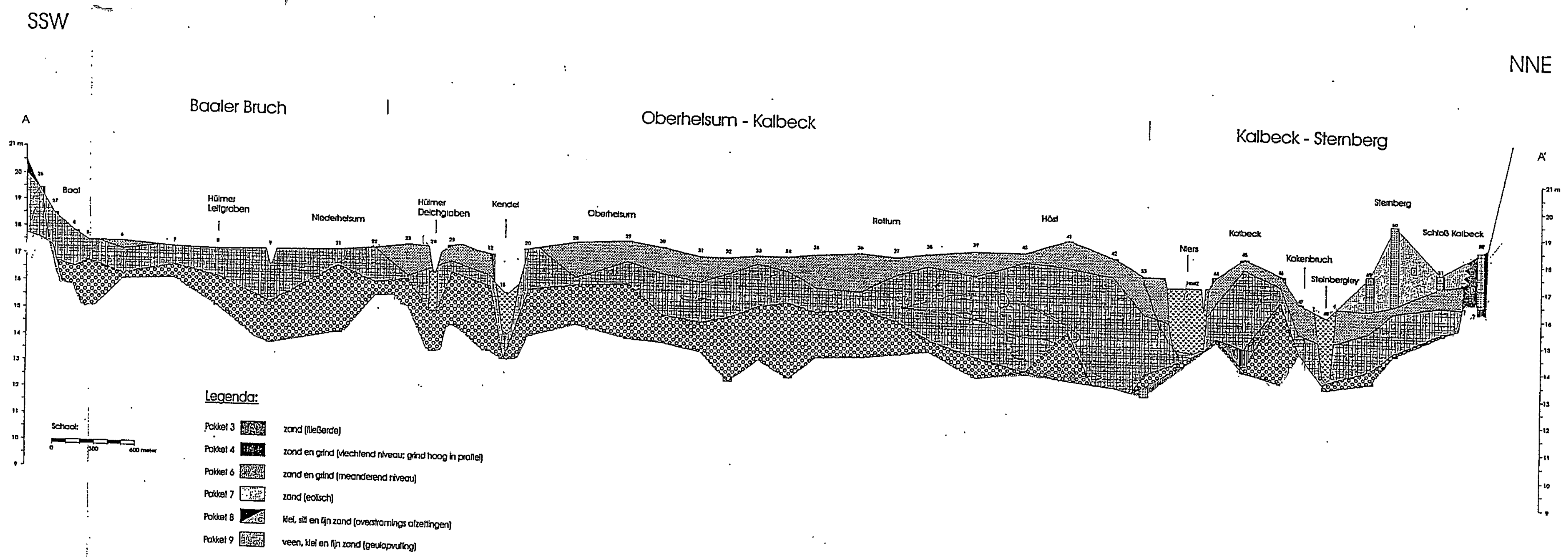
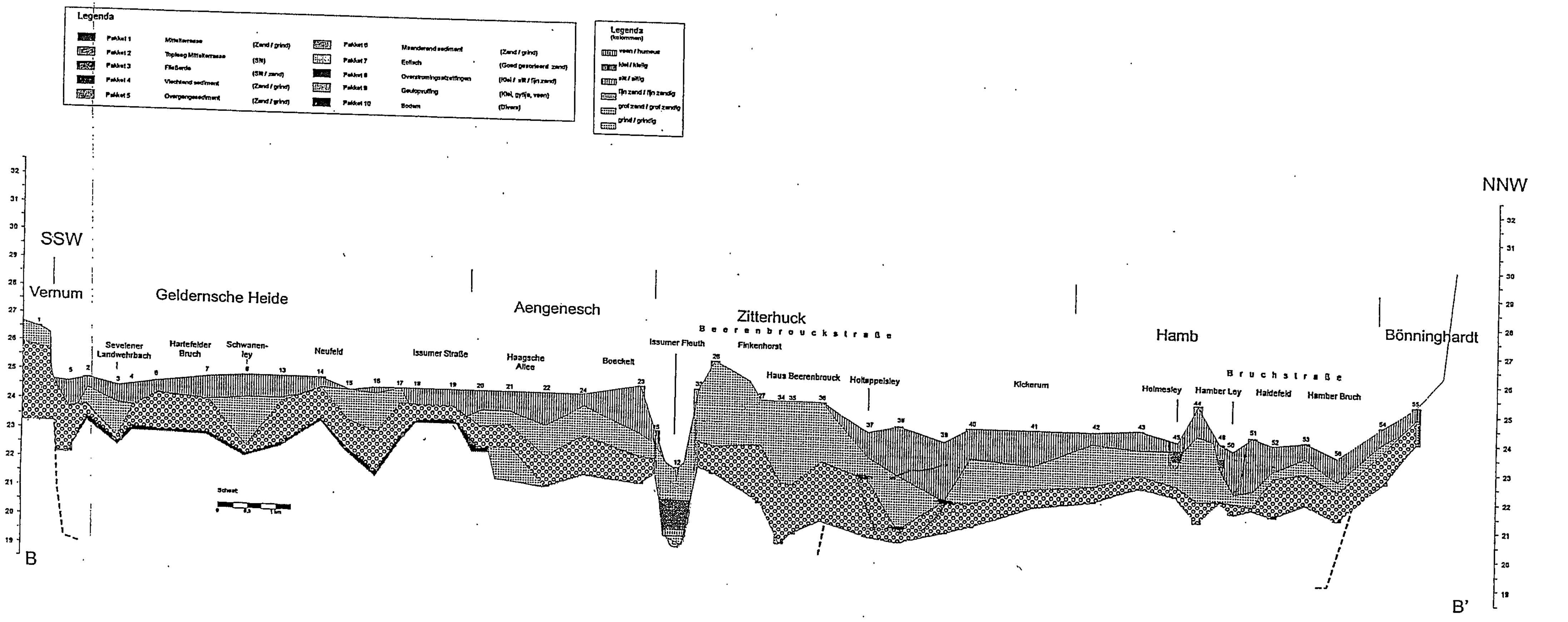

SSW
NNE
A
A'
Baaler Bruch
Oberhelsum - Kalbeck
Kalbeck - Sternberg
Baal
Hülmer Leitgraben
Niederhelsum
Hülmer Deichgraben
Kendel
Oberhelsum
Rottum
Höd
Niers
Kalbeck
Kokenbruch
Steinbergley
Sternberg
Schloß Kalbeck
Legenda:
Pakket 3 zand (fließerde)
Pakket 4 zand en grind (vlechtend niveau; grind hoog in profiel)
Pakket 6 zand en grind (meanderend niveau)
Pakket 7 zand (eolisch)
Pakket 8 klei, silt en fijn zand (overstromings afzettingen)
Pakket 9 veen, klei en fijn zand (geulopvulling)
Schaal:
0
300
600 meter

Fig. 4b : overzichtsprofiel Geldern - Bönninghardt



Three Late Pleniglacial and Late Glacial palaeofloodplain levels have been distinguished above the Holocene floodplain (fig. 2): an oldest level with braiding characteristics at the outer limits of the Niers valley, a transformation level formed during a phase of channel transformation and a level with meandering channel characteristics. It is emphasized that floodplain levels have been distinguished, not terraces, since the different units occur more or less at the same level.

The oldest level has a very subdued morphology and differences in elevation are generally no more than 1 m. The geological maps of the area show slightly elevated gravel bars and connecting and disconnecting channels, suggesting a braided channel pattern during the formation of this level

The transformation level is well expressed along the northern margin of the valley (fig. 2). It is characterized by straight channels and well-developed small meanders. The channels are not wider than 100 m and the thickness of the fine-grained infill is no more than 1.5 m. Infill of the channels is mostly clastic with an alternation of loam and organic loam beds. These palaeochannels seem to represent the transformation from the multi-channel, braided system, when the full valley width of 5 to 10 km was occupied by the river system, to the younger, single-channel meandering system.

The next younger level is characterized by high-sinuosity meandering channels of several generations. The clear cross-cutting relationships enable to establish a relative chronology of the meander scars, especially east of Kevelaer. The palaeomeanders are generally c. 200 m wide and the fine-grained infill is c. 2 to 3 m thick. Bankfull depth may have been more than 5 m. The infill of the older large palaeomeanders consists mostly of loam or peaty loam and peat. The youngest palaeomeander system of the Issumer Fleuth, however, is organic with lacustrine gyttja and peat. Small dune fields occur in association with this last meander belt (presently occupied by the Issumer Fleuth and Niers, see fig. 2).

Fig. 3 Floodplain gradient lines of the successive river systems

It is clear from figure 3 that the successive palaeofloodplain surfaces (braiding-transformational-meandering) have similar elevations and gradients of c. 35-40 cm/km. The transformational and meandering systems show a (normal) downstream decrease in gradient. The reconstructed gradients reveal some important elements:

First, the change in channel pattern of the successive floodplain levels is not related to differences in gradient.

Secondly, neotectonic effects on the river gradients could not be established.

Thirdly, the impact of sea-level changes was negligible during the formation of the floodplain levels.

Fourthly, based on the considerations above, it is postulated that climate change and climate-related changes in water and sediment supply, were the main factors that determined the changes in channel pattern from braiding to meandering.

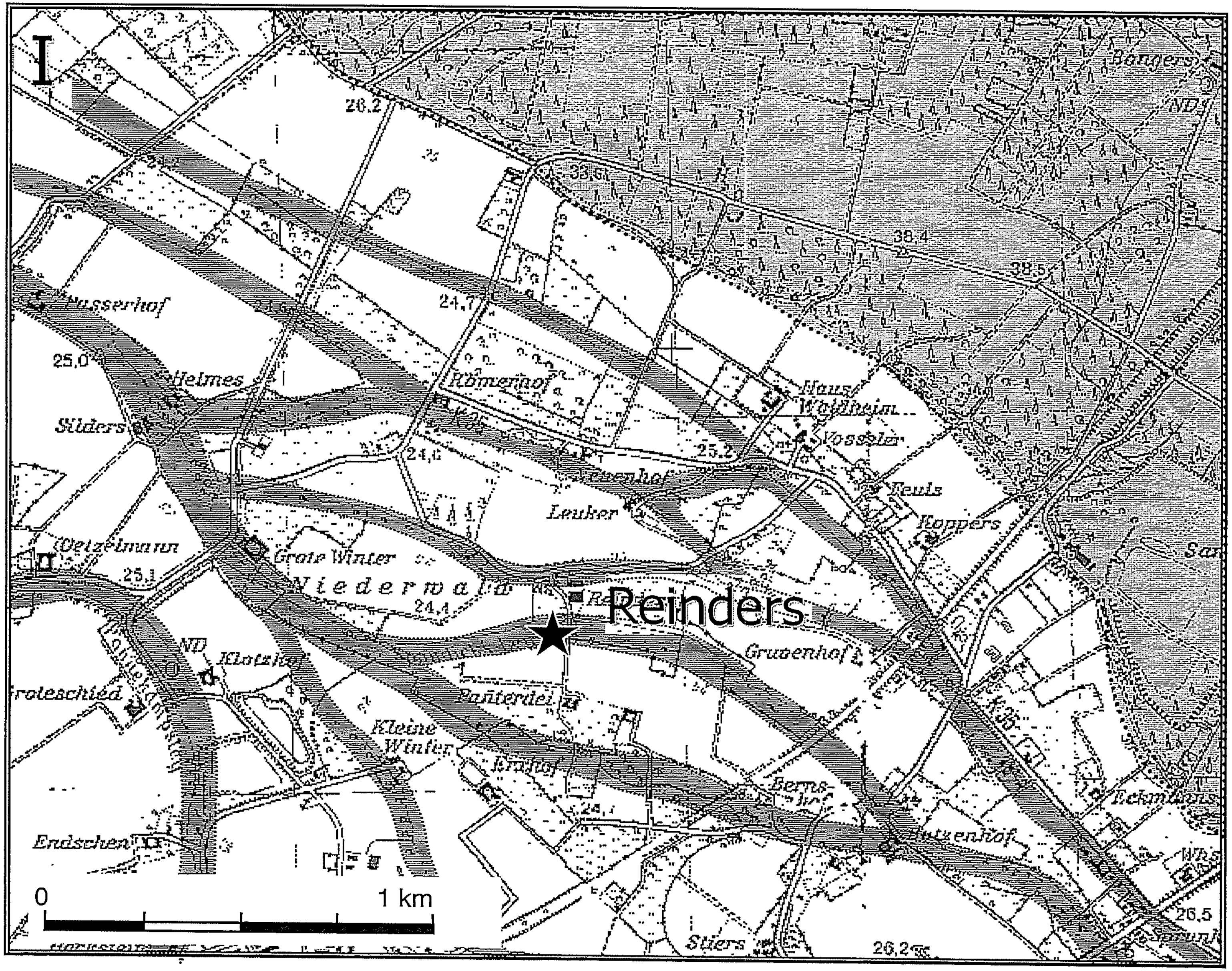

I
Reinders
0
1 km
Bongers
Passerhof
Helmes
Siders
Römerhof
Leuker
Haus Waldheim
Vossler
Teuls
Koppers
Grote Winter
Niederwald
Gruwenhof
Klotzhof
Kleine Winter
Endschen
Stiers
Butzenhof
26,2
33,6
38,4
38,5
24,7
25,0
24,6
25,2
25,1
24,4
26,5

Fig. 4 Lithological cross sections over the Niers valley

Two large-scale coring transects perpendicular to the main valley axis (fig. 4) and many detailed cross-sections over abandoned channels have been made (see fig. 2 for location). It is clear that on a large scale the top of the gravel in the cross sections shows a general dip towards the northeast (fig. 4). In addition to this, in the central part of the profiles the gravel is generally found at a greater depth than at the margins. At the southern margin of the Niers valley, where a braided surface morphology has been found, gravel and gravelly sand is normally found at a shallow depth (average c. 1 m). A loam layer is present at the top of the sequence (Hochflutlehm).
In the area with the transformational river system near Hamb and Oberhelsum (fig. 4a, b) gravelly sediment occurs at a larger depth (c. 1-2 m) and the overlying sand and loam units are more important. In the central part of the valley, with clear large-scale meandering surface patterns, gravel occurs at a depth of 2-4 m. The overlying sandy unit (c. 1-3 m thick) often reveals a clear fining upwards tendency formed by lateral migration of the meandering channels.
Locally, small dune fields are found in association with the last meander generation of the meandering system (fig. 4a: Sternberg; fig. 4b: Finkenhorst).

Fig. 5a Cross section Reinders

This cross section is from the transformation level. Channels are straight to sinuous, small (50 m wide) and shallow (1.5 m). They represent the transformation from the multi-channel, braided system, when the full valley width of 5 to 10 km was occupied by the river system, to the younger, single-channel meandering system. River water flow became more and more concentrated in fewer channels. The fill of the channel is mostly clayey because of clastic influxes from younger channel generations.

Fig. 5b Pollen diagram Reinders

The frequent occurrence of *Picea*, *Abies*, *Corylus*, *Alnus* and high values of Pinus throughout the diagram indicate an allochthonous component in the whole pollen diagram. This hampers the interpretation of the pollen diagram.
The lower part of the diagram, from 155 to 117 cm, shows a gradual *Pinus* decrease and increase of the Gramineae values. The high *Pinus* values at the base coincide with a sandy clay lithology and can probably be attributed to reworking. The continuous presence of *Hippophaë* is a strong indication for the Early Dryas biozone (c. 12,1-11,9 ka ^{14}C BP). The upper part from 117 to 80 cm is strongly dominated by high *Pinus* values. Theoretically, these high Pine values could be part of the Preboreal Pinus phase, however, typical elements for the early Holocene like Monolete psilate spores and *Typha latifolia* are missing and therefore this part of the diagram predates the Holocene. Most likely, the interval from c. 95 to 117 cm represents the *Pinus* phase of the late Allerød (c.

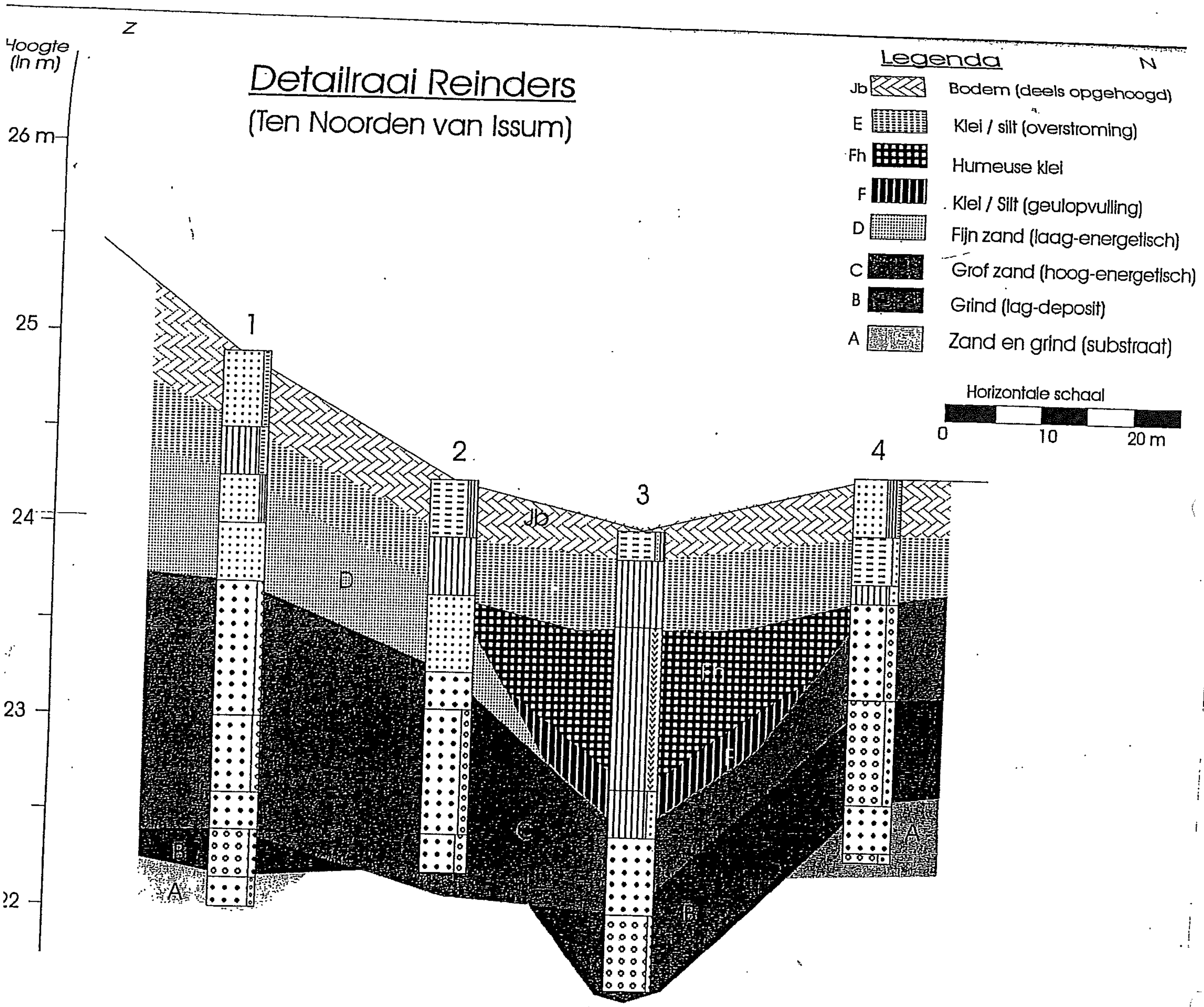

Z
N
Hoogte (in m)
26 m
25
24
23
22
Detailraai Reinders
(Ten Noorden van Issum)
Legenda
Jb Bodem (deels opgehoogd)
E Klei / silt (overstroming)
Fh Humeuse klei
F Klei / Silt (geulopvulling)
D Fijn zand (laag-energetisch)
C Grof zand (hoog-energetisch)
B Grind (lag-deposit)
A Zand en grind (substraat)
Horizontale schaal
0
10
20 m
1
2
3
4
Jb
D
Fh
F
C
B
A

Fig. 5a

Fig. 5b

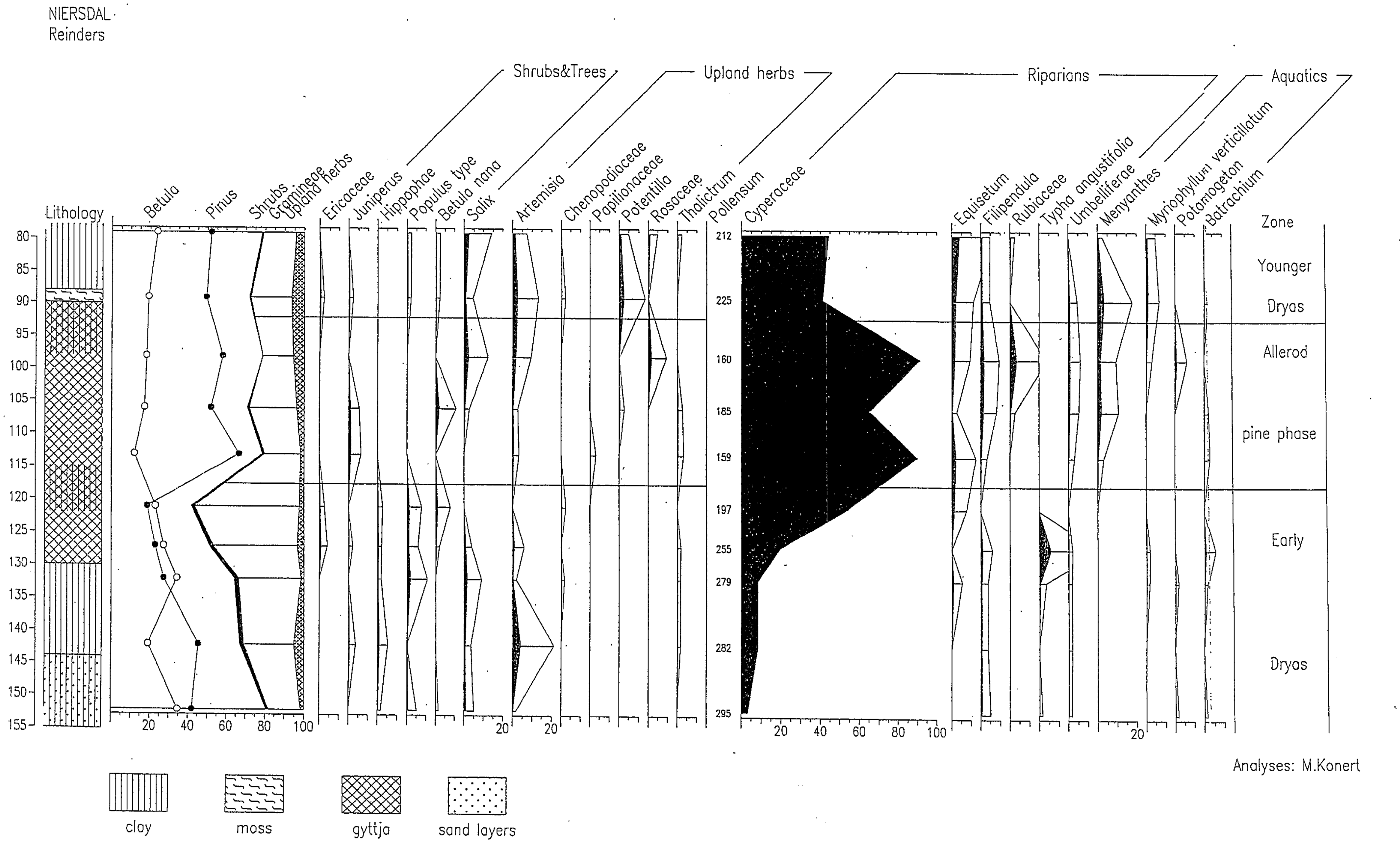
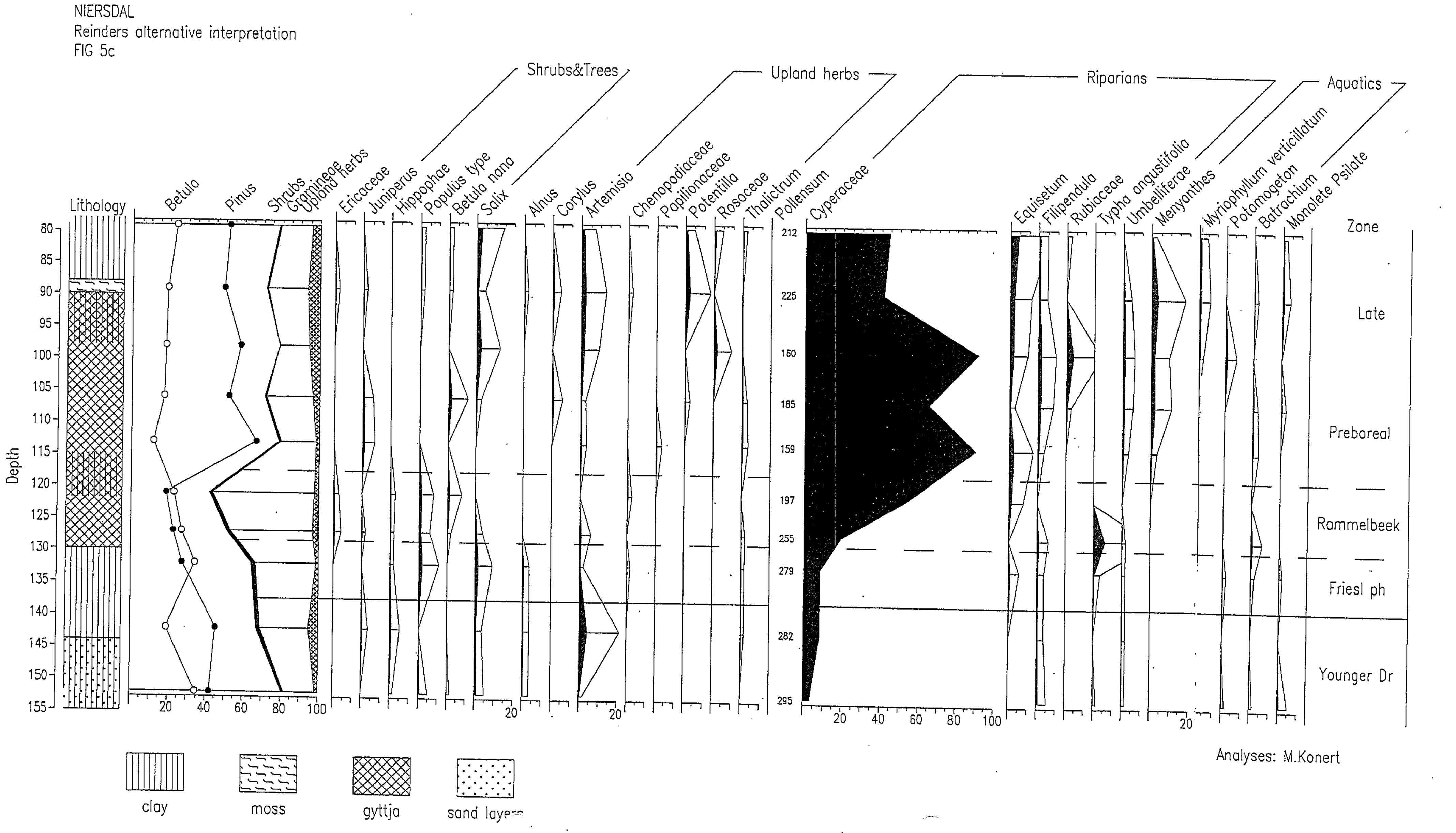

NIERSDAL
Reinders
Shrubs&Trees
Upland herbs
Riparians
Aquatics
Lithology
Betula
Pinus
Shrubs
Gramineae
Upland herbs
Ericaceae
Juniperus
Hippophae
Populus type
Betula nana
Salix
Artemisia
Chenopodiaceae
Papilionaceae
Potentilla
Rosaceae
Thalictrum
Pollensum
Cyperaceae
Equisetum
Filipendula
Rubiaceae
Typha angustifolia
Umbelliferae
Menyanthes
Myriophyllum verticillatum
Potamogeton
Batrachium
Zone
Younger
Dryas
Allerod
pine phase
Early
Dryas
clay
moss
gyttja
sand layers
Analyses: M.Konert

Fig. 5c


NIERSDAL
Reinders alternative interpretation
FIG 5c
Shrubs&Trees
Upland herbs
Riparians
Aquatics
Lithology
Betula
Pinus
Shrubs
Gramineae
Upland herbs
Ericaceae
Juniperus
Hippophae
Populus type
Betula nana
Salix
Alnus
Corylus
Artemisia
Chenopodiaceae
Papilionaceae
Potentilla
Rosaceae
Thalictrum
Pollensum
Cyperaceae
Equisetum
Filipendula
Rubiaceae
Typha angustifolia
Umbelliferae
Menyanthes
Myriophyllum verticillatum
Potamogeton
Batrachium
Monolete Psilate
Zone
Late
Preboreal
Rammelbeek
Friesl ph
Younger Dr
Depth
80
85
90
95
100
105
110
115
120
125
130
135
140
145
150
155
212
225
160
185
159
197
255
279
282
295
20
40
60
80
100
clay
moss
gyttja
sand laye
Analyses: M.Konert

11,2-10,9 ka ^{14}C BP). This interpretation implies a hiatus at 117 cm covering the *Betula* phase of the Allerød.
From c. 95 cm upwards there is a gradual increase in *Artemisia, Pediastrum* and *Salix*, probably reflecting the climatic cooling of the Younger Dryas period.

The age of the basal part of the fill indicates that the transformation from a braided to a meandering system occurred during or shortly before the Early Dryas period (c. 12,1 ka ^{14}C BP). After abandonment the channel scar was frequently inundated and filled with clastic suspension material from younger meandering channel generations during the Allerød and Younger Dryas.
The dates indicate that the change in fluvial style does not coincide with the early Late Glacial climate amelioration (at c. 12,5 ka ^{14}C BP) and climate-related hydrological changes. The fluvial response seems to be delayed by c. 400 years (transitional phase) which can be related to the gradual Late Glacial development of the vegetation cover and related changes in water discharge (more regular) and sediment supply (decreasing input).
Three levels of the boring Reinders were analyzed for macro botanical remains in order to collect material for AMS C-14 dates. These levels are 128-130 cm, 111-113 cm and 88-90 cm. We are still waiting for the results. Although a Lateglacial age was anticipated, the macro botanical assemblage did not seem to agree with this. The 128-130 cm level contained fruits of *Betula verrucosa* (15) besides fruits of *Betula pendula* (2). Betula verrucosa is a species, which is not normaly found in deposits of Late Glacial age. The species intermingles in the vegetation only from the Preboreal onwards. Another species that argues against a Late Glacial age of the infill is the occurrence of Alisma plantago aquatica. Its present day NW European distribution is limited to south Sweden and south Finland and it doesn't seem to occur more north. An alternative interpretation and zonation of pollenrecord Reinders is depicted in fig.5c

Fig. 6a Cross section Bons A

This cross section is from the high-sinuosity meandering system. The palaeomeander is circa 200 m wide. The cross section is clearly asymmetric with the stoss side at the left. The fill is 2 to 2.5 m thick and consists of clay at the base overlain by organic material. Palaeodischarge calculations reveal that the palaeoNiers-Rhine discharge was c. 10 to 20 % of the present-day Rhine discharge, indicating that during the Late Glacial probably a more northerly course co-existed with the Niers-Rhine.

Fig. 6b: Pollen diagram Bons A

The lower part of the fill below 162 cm is clastic in nature and characterized by high *Pinus* values. In addition, some *Alnus* and Carpinus pollen is present and therefore it is likely that part of the *Pinus* pollen has been reworked. The presence of *Empetrum*, A*rtemisia, Helianthenum* and *Pediastrum* indicates the (final phase of the) Younger Dryas period (c. 10,9-10,1 ka ^{14}C BP). *Juniperus* attains maximum values towards the end of this zone and marks the transition to the Holocene. It is succeeded by an increase

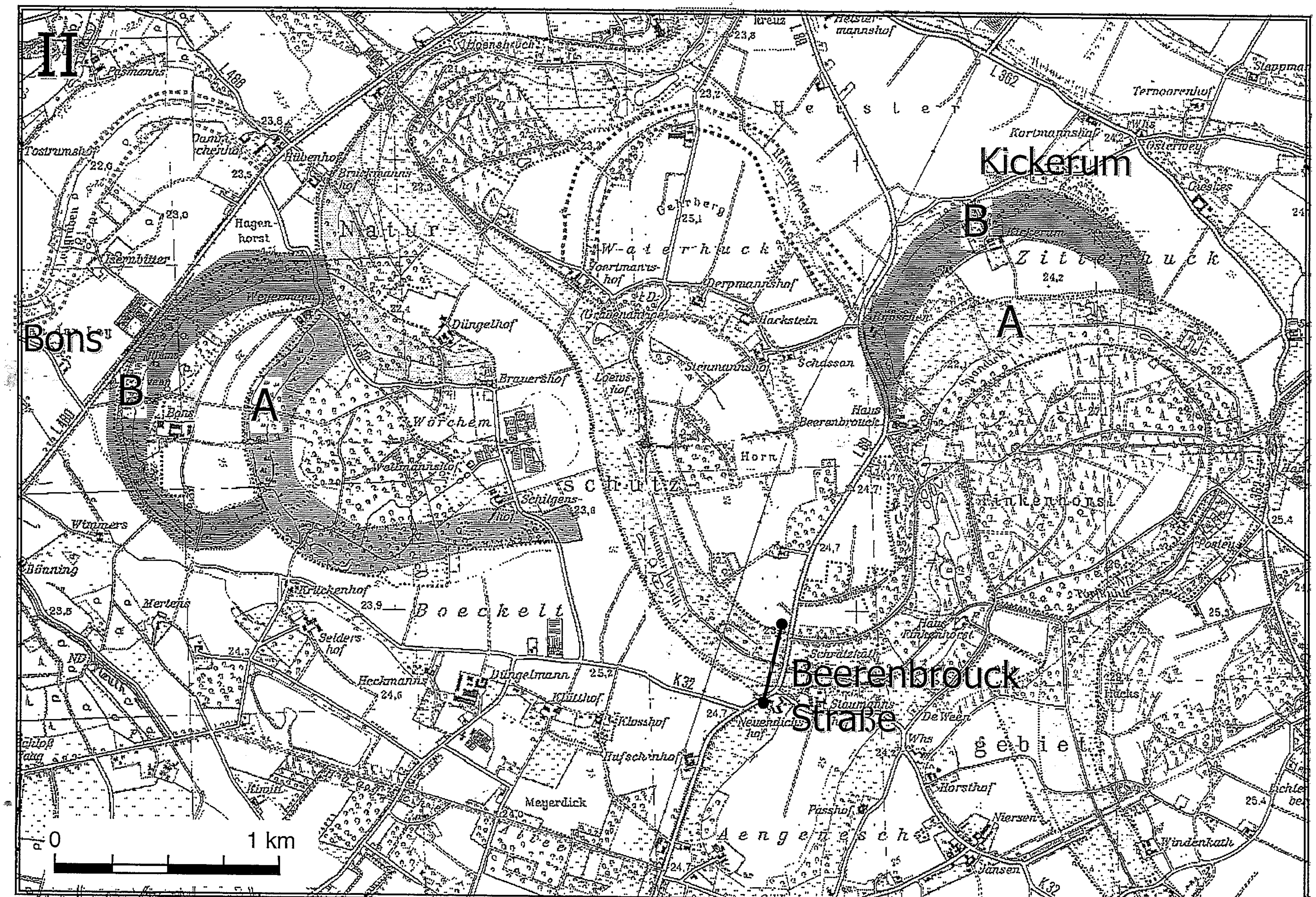
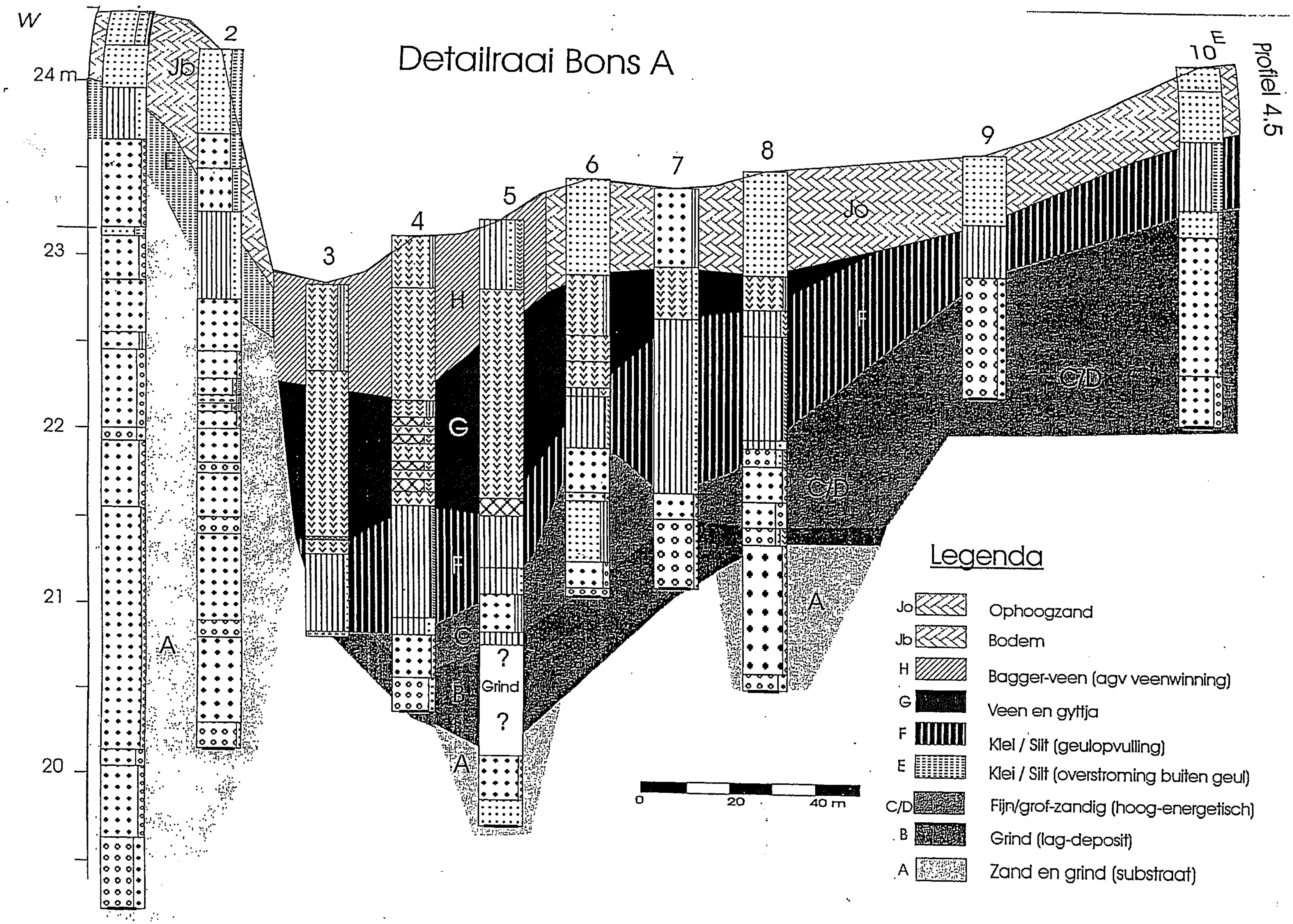

II
Bons
B
A
Kickerum
B
A
Beerenbrouck
Straße
0
1 km
Natur
Worchem
Boeckelt
Schultz
Gehrberg
Waterhuck
Zitterhuck
Heusler
Aengenesch
gebiet
Hagenhorst
Düngelhof
Brauershof
Derpmannshof
Haus Beerenbrouck
Horn
Heckmanns
Düngelmann
Meyerdick
Klosshof
Hufschenhof
Passhof
Horsthof
Niersen
Jansen
Windenkath
Ternoorenhof
Kortmannshof
Seidershof
Mertens
Wimmers
Bönning
Tostrumshof
Kembitter
Hübenhof
Weyermann
Schilgenshof
Staumanns
De Ween
Schassan
Hackstein
Stemmannshof
L 362
L 488
L 89
K 32

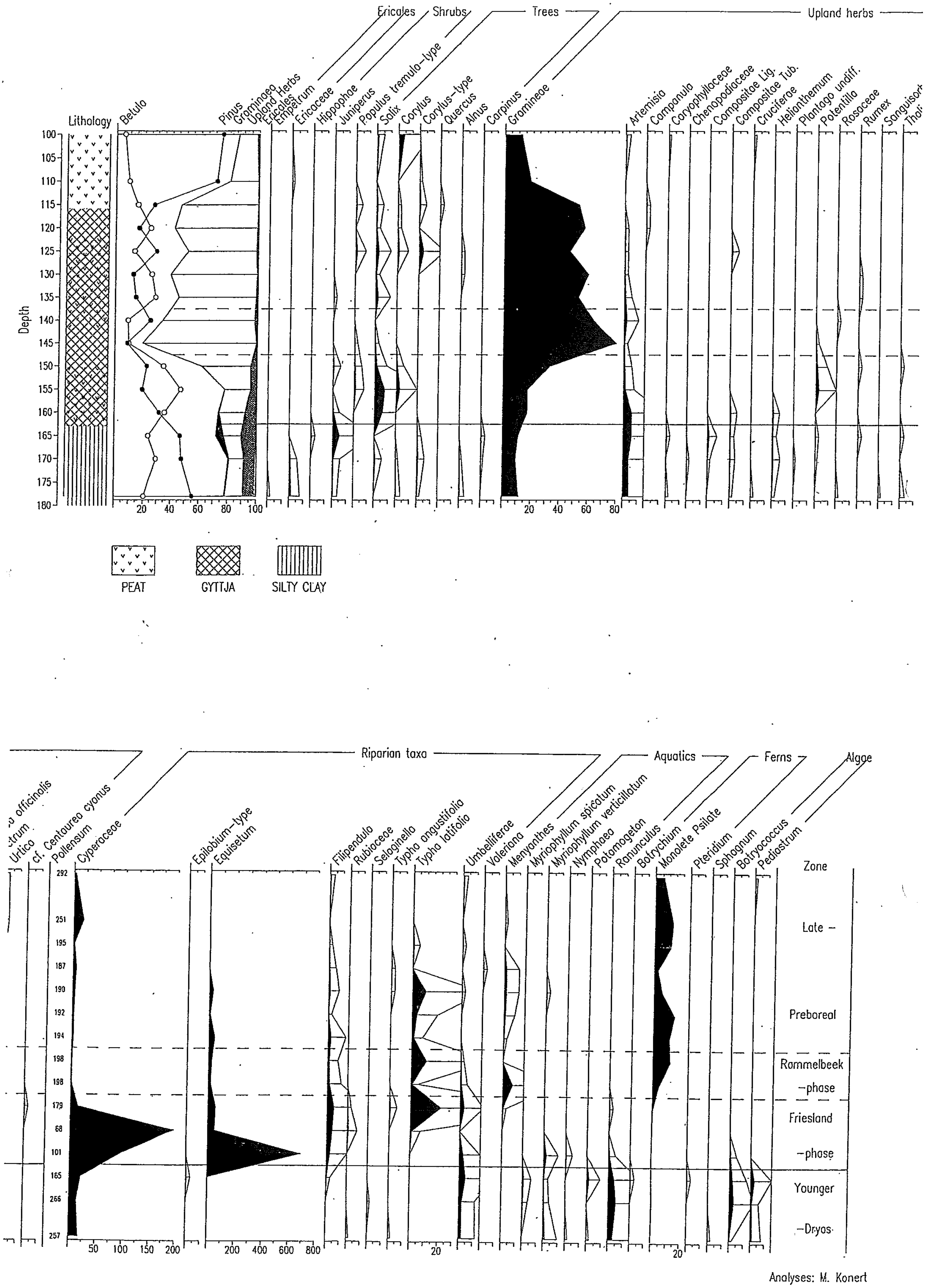
Fig. 6a



Detailraai Bons A
W
E
Profiel 4.5
24 m
23
22
21
20
2
3
4
5
6
7
8
9
10
Jb
Jo
E
H
G
F
C/D
B
A
?
Grind
0
20
40 m
Legenda
Jo Ophoogzand
Jb Bodem
H Bagger-veen (agv veenwinning)
G Veen en gyttja
F Klei / Silt (geulopvulling)
E Klei / Silt (overstroming buiten geul)
C/D Fijn/grof-zandig (hoog-energetisch)
B Grind (lag-deposit)
A Zand en grind (substraat)

NIERSDAL
Bons A4

Fig. 6b



of *Betula* that represents the Preboreal *Betula* phase (147-162 cm). The increase of *Filipendula* and *Typha latifolia* is also characteristic for the start of the Holocene. The Younger Dryas to Holocene boundary fully coincides with a change in lithology from clay to peat at 162 cm, indicating a change in the fluvial regime (see discussion). From 137-147 cm *Betula* has declined and Gramineae values reach a maximum.This zone is equivalent with the Rammelbeek phase (c. 9,9-9,7 ka ^{14}C BP). Although the Gramineae values remain high, *Betula* shows an increase again at 137 cm, which is interpreted as the start of the late Preboreal *Betula* phase. The strong increase of *Pinus* at 112 cm is the start of the late late Preboreal *Pinus* phase (100-112 cm).

The lowermost spectra of the infill are from the Younger Dryas period. This biostratigraphical interpretation indicates that the Bons infill is older than the Beerenbrouck/Kickerum A infill which is also supported by the geomorphological evidence (fig. 2). This finding indicates that the Bons meander was abandoned during the Younger Dryas and that a meandering system was active in the Niers valley during or before the Younger Dryas stadial (Allerød).

Fig. 7a Cross section Beerenbrouckstrasse

The cross section is from the last generation of high-sinuosity meanders, formed just before the final abandonment of the Niers-Rhine valley (fig. 2). The fine-grained infill shows an asymmetric channel form with the stoss side at the left (south). The palaeomeander is circa 250 m wide and the fine-grained fill is c. 2.5 m thick. In contrast to older meander channels clay is only present at the flanks of the channel. In the deepest part of the channel the fill consists of calcareous gyttja changing upward into peat. Small dune fields occur in association with this last meander belt (see fig. 2), indicating deflation of temporarily dry channels or pointbar slopes, possibly related to increased discharge fluctuations.

Fig. 7b Pollen diagram Kickerum A

Cross section Beerenbrouckstrasse has not been sampled for pollen analysis. Instead, cross section Kickerum A, located in the same meander channel, was analysed.
The lower part, below 172 cm, of the diagram is characterized by Pinus and Betula and shows a strong dominance of the Gramineae. This zone is indicative for the early Preboreal Rammelbeek phase (c. 9,9-9,7 ka ^{14}C BP). It could be argued, because of the low arboreal pollen values, that this zone is part of the Younger Dryas biozone, However, the absence of *Empetrum* and low value of *Juniperus* exclude a Younger Dryas age. The overlying zones are dominated by *Betula* (142-172 cm) and *Pinus* (117-142 cm) and are correlated with the late Preboreal *Betula* and *Pinus* phases. The upper part of the diagram, with increasing *Corylus*, and low *Quercus* and *Ulmus* values, is indicative for the start of the Boreal (c. 9,1 ka ^{14}C BP).
The age of the basal fine-grained fill shows that the large-scale meandering Niers-Rhine system was abandoned at the Weichselian to Holocene boundary or in the very early Holocene. Therefore, the Niers-Rhine was still active during the Younger Dryas period. This contrasts with previous findings in which the final abandonment of the Niers-Rhine

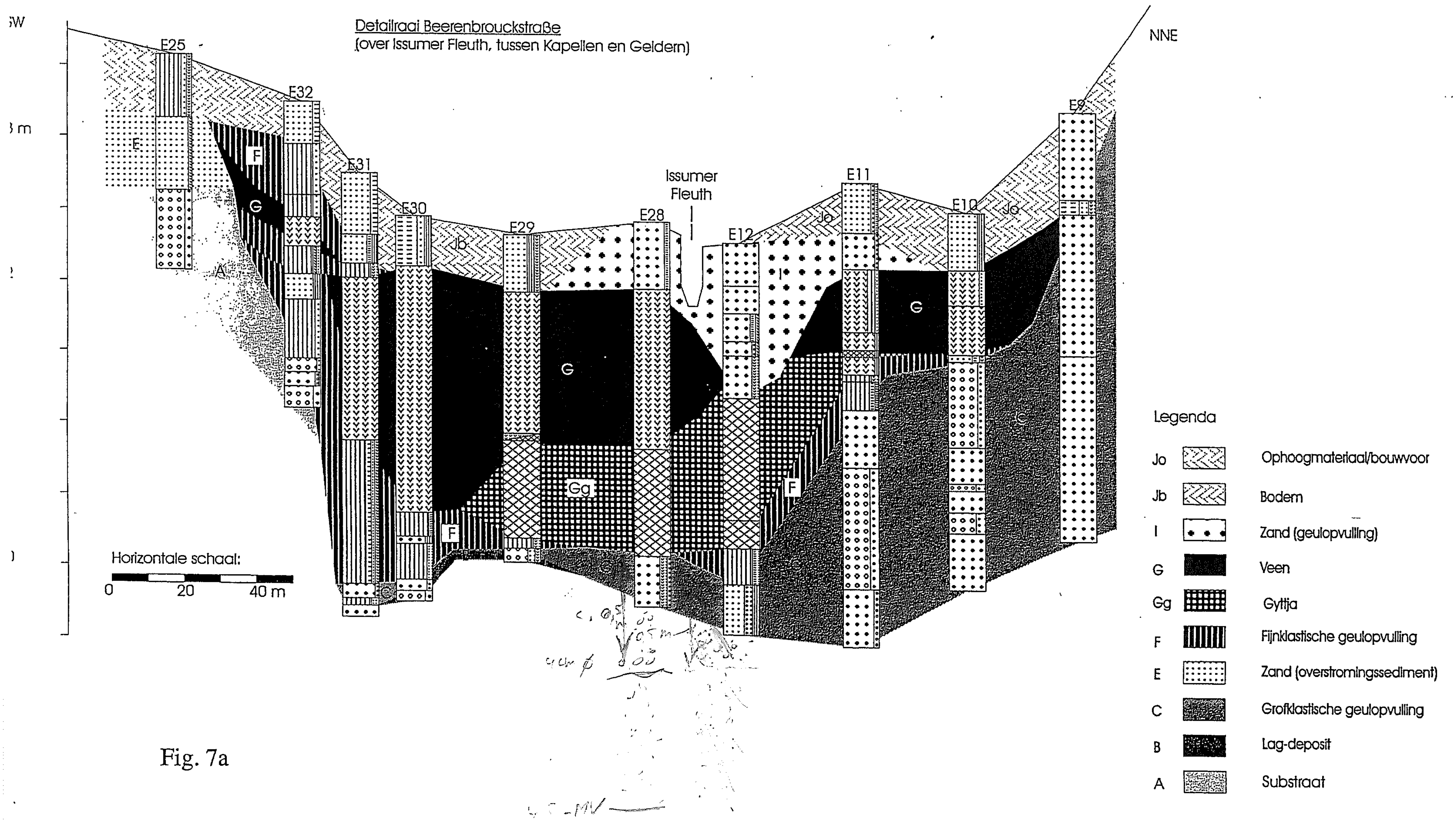
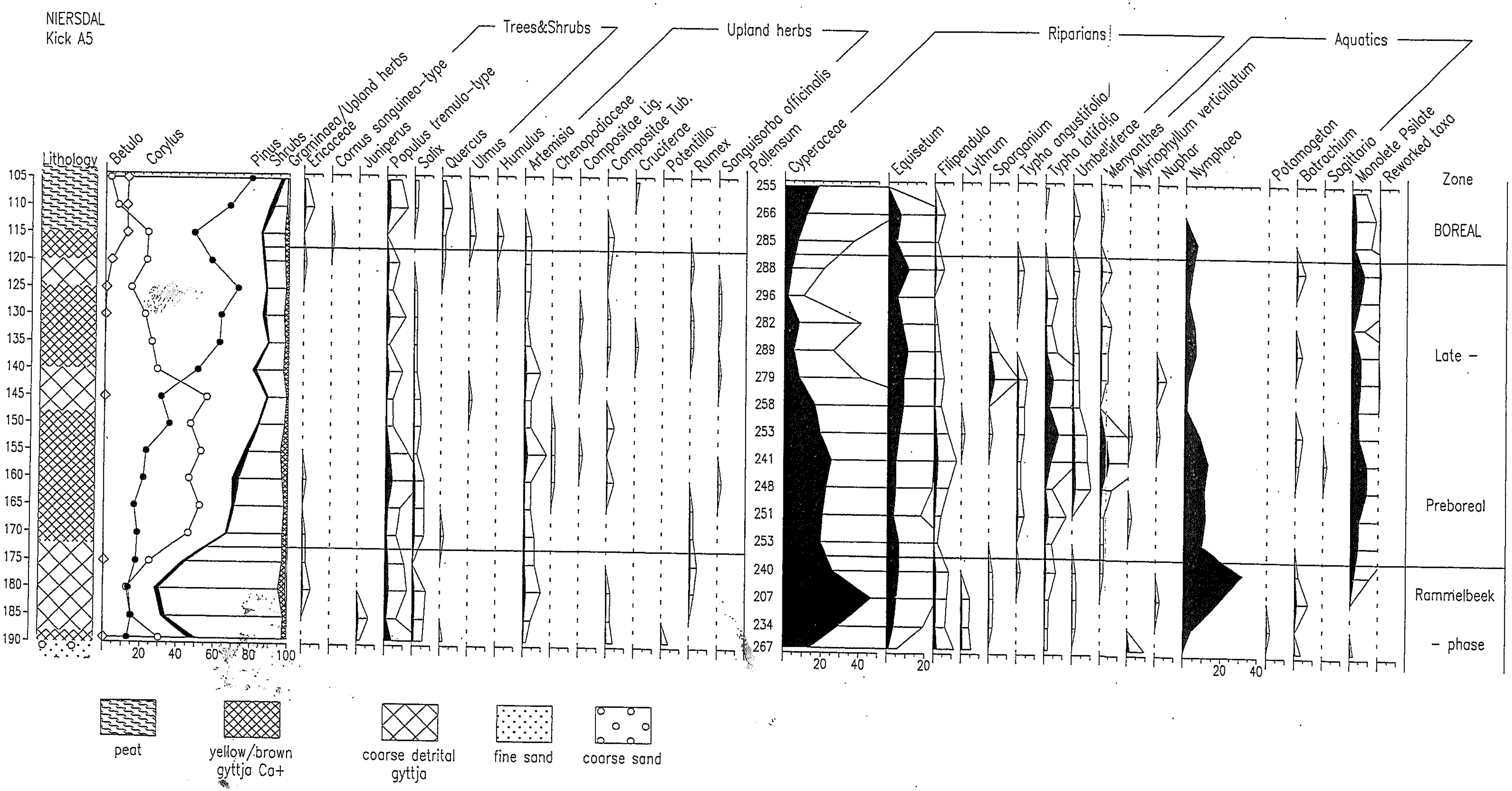

Detailraai Beerenbrouckstraße
(over Issumer Fleuth, tussen Kapellen en Geldern)
SW
NNE
E25
E32
E31
E30
E29
E28
E12
E11
E10
E9
Issumer Fleuth
Jo
Jb
I
G
Gg
F
E
A
Horizontale schaal:
0
20
40 m
Legenda
Jo Ophoogmateriaal/bouwvoor
Jb Bodem
I Zand (geulopvulling)
G Veen
Gg Gyttja
F Fijnklastische geulopvulling
E Zand (overstromingssediment)
C Grofklastische geulopvulling
B Lag-deposit
A Substraat

Fig. 7a

Fig. 7b


NIERSDAL
Kick A5
Trees&Shrubs
Upland herbs
Riparians
Aquatics
Lithology
Betula
Corylus
Pinus
Shrubs
Gramineae/Upland herbs
Ericaceae
Cornus sanguinea-type
Juniperus
Populus tremula-type
Salix
Quercus
Ulmus
Humulus
Artemisia
Chenopodiaceae
Compositae Lig.
Compositae Tub.
Cruciferae
Potentilla
Rumex
Sanguisorba officinalis
Pollensum
Cyperaceae
Equisetum
Filipendula
Lythrum
Sparganium
Typha angustifolia/
Typha latifolia
Umbelliferae
Menyanthes
Myriophyllum verticillatum
Nuphar
Nymphaea
Potamogeton
Batrachium
Sagittaria
Monolete Psilate
Reworked taxa
Zone
BOREAL
Late -
Preboreal
Rammelbeek
- phase
105
110
115
120
125
130
135
140
145
150
155
160
165
170
175
180
185
190
20
40
60
80
100
255
266
285
288
296
282
289
279
258
253
241
248
251
253
240
207
234
267
peat
yellow/brown gyttja Ca+
coarse detrital gyttja
fine sand
coarse sand

course was placed before the end of the Allerød (Verbraeck, 1984). Furthermore, it shows that the Niers-Rhine was a meandering system during the Younger Dryas, in contrast to the nearby Maas river (Kasse et al., 1995).

Stop Ottersum: underfit Niers

The present day brooks of the Issumer Fleuth in the east, the Niers (draining the older terrace surfaces) from the south and Kendel in the west follow the former meandering courses of the Late Glacial Niers-Rhine. They can be described as underfit streams with smaller meander wavelength and amplitude in comparison to the Late Glacial system.

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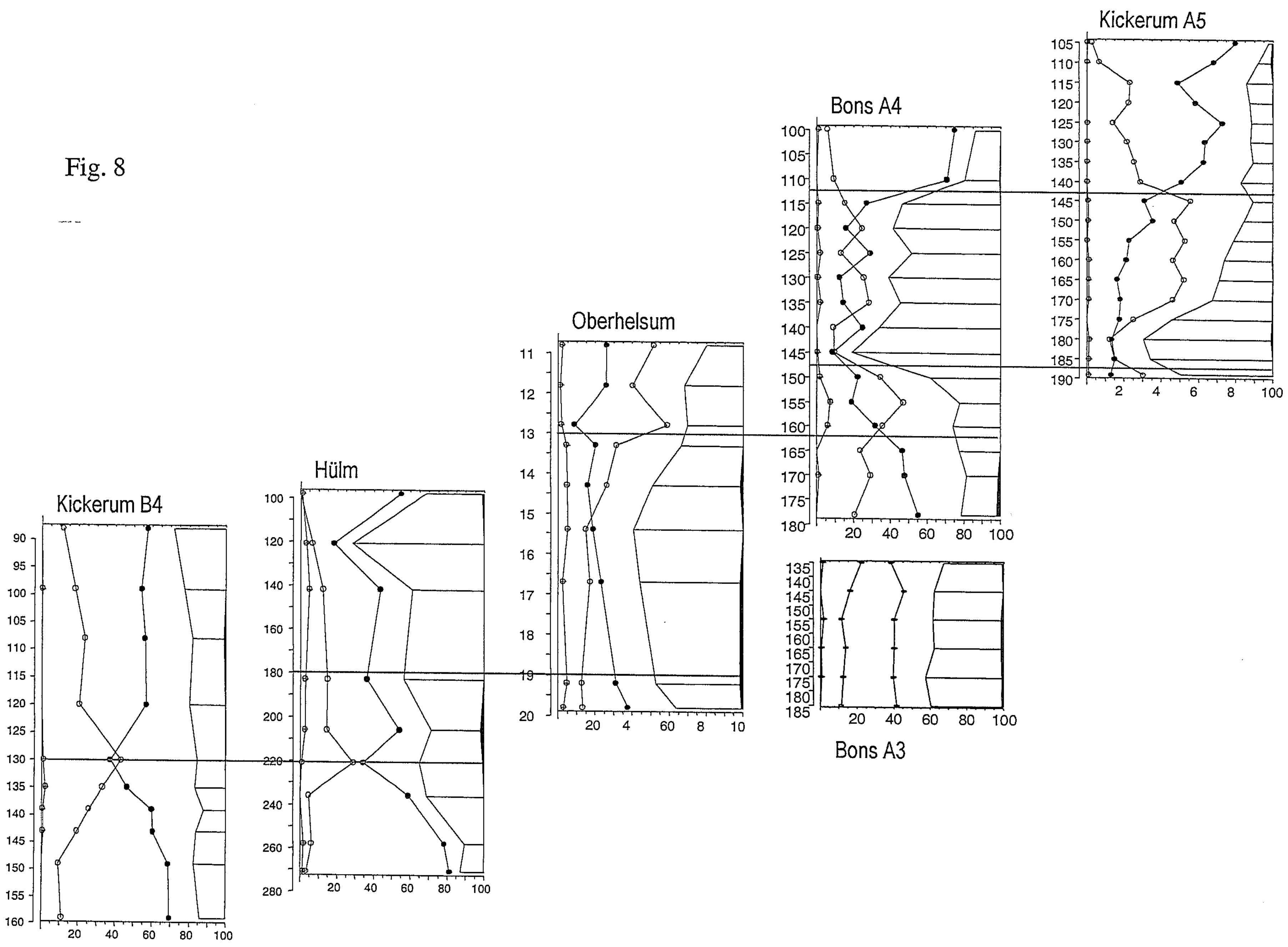
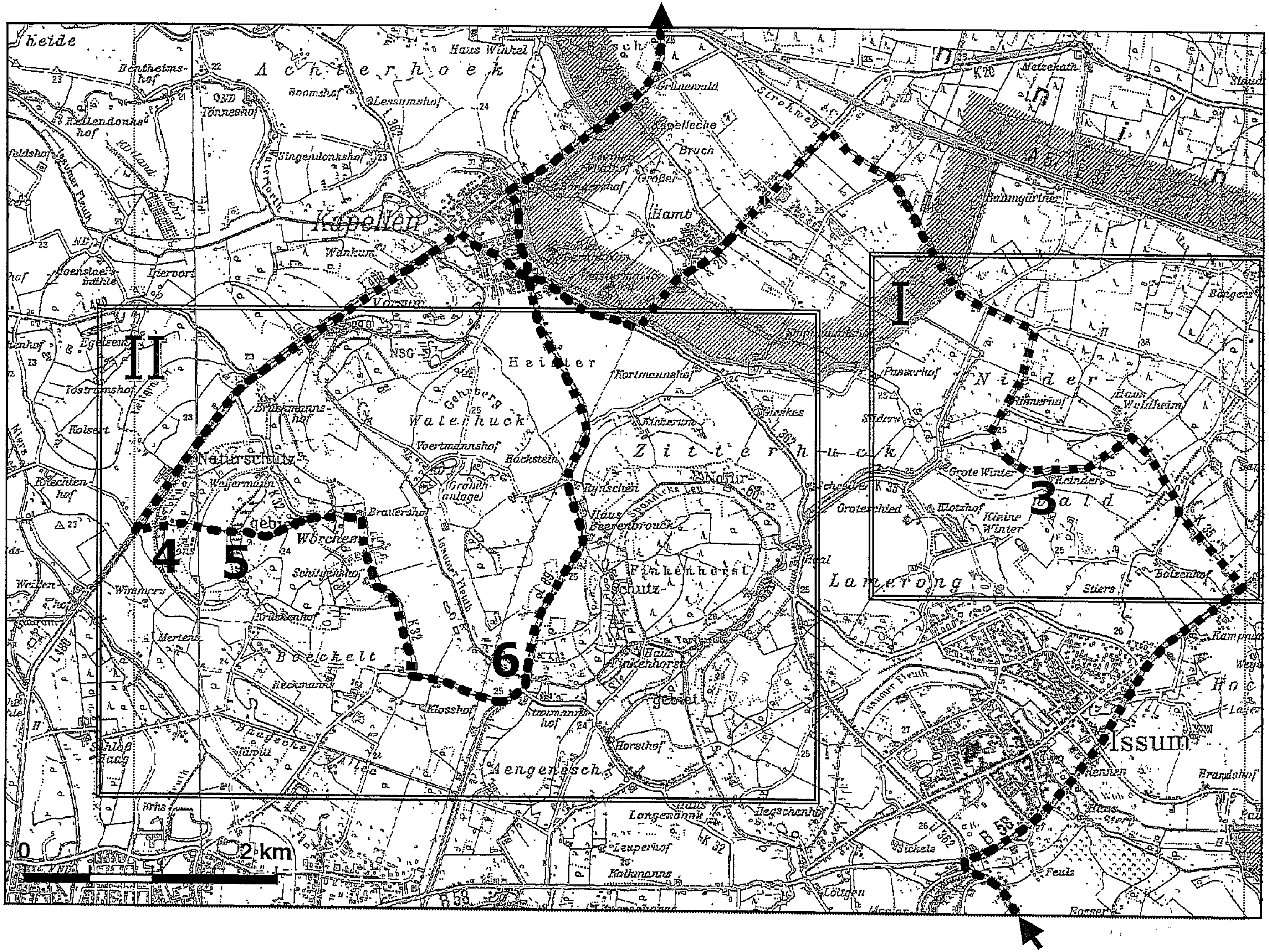
Tabel 1:

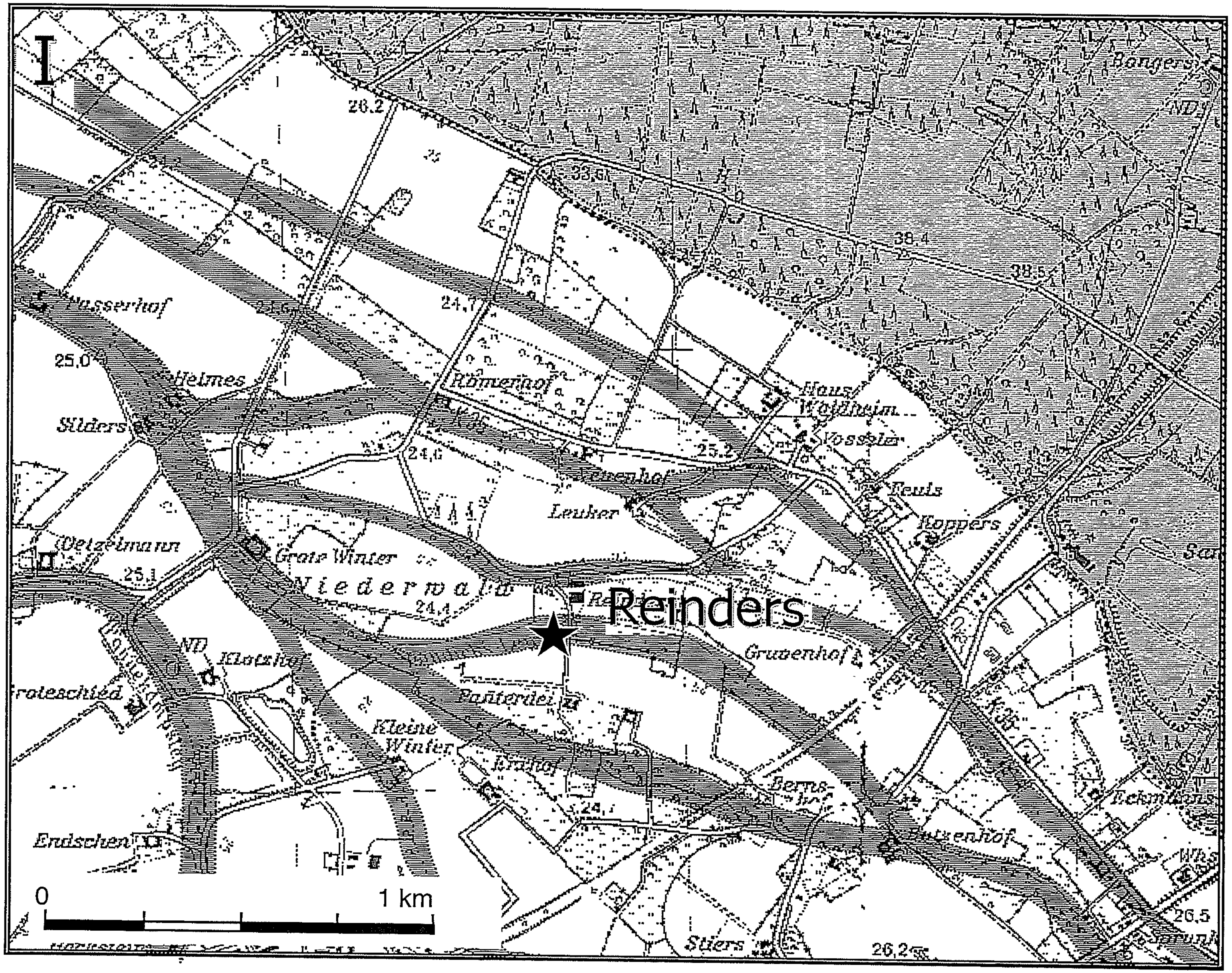
Comparison between the biostratigraphical sub-division of the Lateglacial and Early Holocene in The Netherlands and parts of north-western Germany.

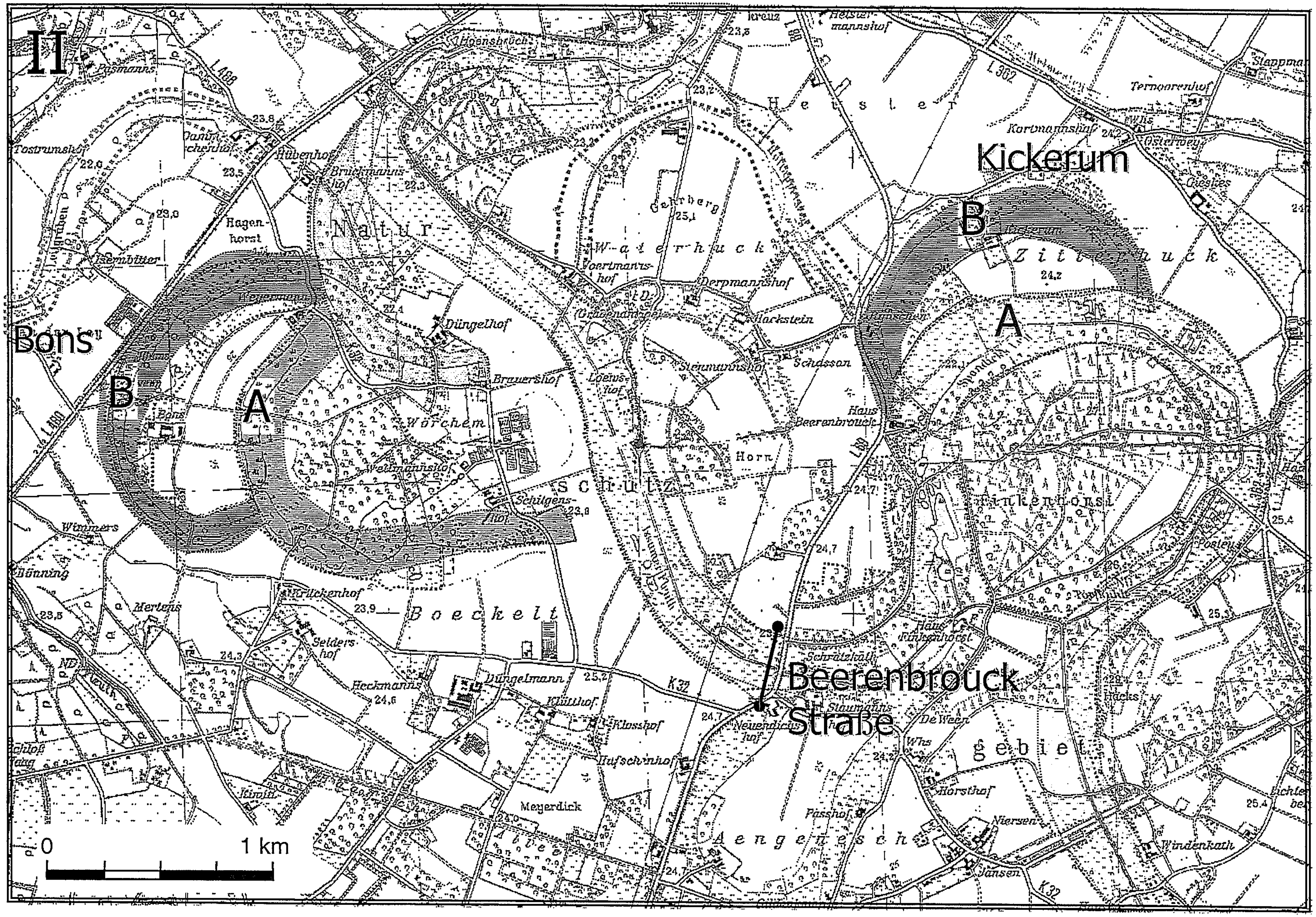
age BP	Biostratigraphy Netherlands (Hoek, 1997)		Biostratigraphy north-western Germany (Menke, 1985; Behre, 1996)
9,150			
	5	Late Preboreal	Boreal
9,500			
	4c		Präboreal c
9,750			
	4b	Early Preboreal	Präboreal b
9,950			
	4a		Präboreal a
10,150			
	3b		
10,550		Late Dryas	Jüngere Dryas
	3a		
10,950			
	2b		Alleröd
11,250			
	2a2	Allerød	Mitteler Dryas
11,500			
	2a1		Bölling
11,900			
	1c	Earlier Dryas	Älteste Dryas
12,100			
	1b	Bølling	
12,450			Meiendorf
	1a	Earliest Dryas	
12,900			Artemisia rise
	LP	Late Pleniglacial	Pleniglazial

Fig. 8




I
II
3
4
5
6
0
2 km
Issum
Kapellen
Achterhoek
Haus Winkel
Grünewald
Kapelleche
Bruch
Hamb
Heister
Waterhuck
Zitterhuck
Naturschutz
Weijermann
Boeckelt
Finkenhorst
Nieder
Bald
Lamerong
Aengenesch
Langemann
Kalkmanns
Leuperhof
Klosshof
Brattershof
Voertmannshof
Rortmannshof
Tostramshof
Kolsert
Wimmers
Mertens
Reckmanns
Metzekath
Baumgärtner
Haus Waldheim
Grote Winter
Kleine Winter
Klotzhof
Groterchied
Stiers
Bolzenhof
Brandshof
Feuls
Sickels
Lötgen
Keide
Bentheims-hof
Boomshof
Lessumshof
Tönneshof
Kellendonks hof
Singendonkshof
Wankum
Strohweg
Hoenstaes mühle
Egelsenhof
Pusserhof
Stiers
Bangers
Haus Finkenhorst
Haus Beerenbrouck
Horsthof
Stuumannshof
Rennen
Haus Stery


I
Reinders
Niederwald
Bangers
Haus Waldheim
Vossler
Teuls
Koppers
Römerhof
Neuenhof
Leuker
Gruvenhof
Wasserhof
Helmes
Sliders
Wetzelmann
Grote Winter
Kleine Winter
Klotzhof
Pasterdei
Erkhof
Bernshof
Putzenhof
Eckmanns
Stiers
Endschen
Groteschied
Whs
26,2
33,6
38,4
38,5
24,7
24,6
25,0
25,2
24,0
25,1
24,4
24,1
26,5
0
1 km


II
Kickerum
Bons
Beerenbrouck
Straße
A
B
A
B
0
1 km
Natur
schutz
gebiet
Heister
Waterhuck
Zitterhuck
Boeckelt
Wörchem
Horn
Aengenesch
Meyerdick
Hagen-
horst
Düngelhof
Brauershof
Derpmannshof
Hackstein
Schasson
Haus
Beerenbrouck
Düngelmann
Heckmanns
Krückenhof
Seldershof
Hufschmihof
Klosshof
Kliitthof
Horsthof
Niersen
Jansen
Windenkath
Passhof
Mertens
Bünning
Wimmers
Tostrumshof
Ternoorenhof
Kortmannshof
Osterweg
Giesges
Hübenhof
Hoenshof
Gerberg
Gehrberg
Stemmannshof
Loewshof
Schilgenshof
Wellmannshof
L 362
L 488
L 480
K 32
L 80
L 39